

Amendments to the Claims:

Please cancel claim 4127 without prejudice.

This listing of claims will replace all prior versions and/or listings of claims in the application:

Listing of Claims:

1-4090. (cancelled)

4091. (currently amended): A system configured to heat a hydrocarbon containing formation, comprising:

one or more heaters disposed in one or more open wellbores in the formation, wherein the one or more heaters are configured to provide heat to at least a ~~portion~~ section of the formation during use;

wherein the system is configured to allow heat to transfer from the one or more heaters to a part of the formation during use; ~~and~~

wherein the system is configured to maintain a temperature in the part of the formation in a pyrolysis temperature range; and

wherein the system is configured to provide H₂ to at least some of the formation.

4092. (previously presented): The system of claim 4091, wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

4093. (previously presented): The system of claim 4091, wherein at least one of the heaters comprises an electrical heater.

4094. (cancelled)

4095. (previously presented): The system of claim 4091, wherein at least one of the heaters comprises a flameless distributed combustor.

4096. (previously presented): The system of claim 4091, wherein at least one of the heaters comprises a natural distributed combustor.

4097. (previously presented): The system of claim 4091, wherein at least one of the open wellbores comprises a diameter of at least approximately 5 cm.

4098. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation.

③ 4099. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein the overburden casing comprises steel.

4100. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein the overburden casing is disposed in cement.

4101. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein a packing material is disposed at a junction of the overburden casing and at least one of the open wellbores.

4102. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, wherein a packing material is disposed at a junction of the

overburden casing and at least one of the open wellbores, and wherein the packing material is configured to substantially inhibit a flow of fluid between at least one of the open wellbores and the overburden casing during use.

4103. (previously presented): The system of claim 4091, further comprising an overburden casing coupled to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, wherein a packing material is disposed at a junction of the overburden casing and at least one of the open wellbores, and wherein the packing material comprises cement.

4104. (previously presented): The system of claim 4091, wherein the system is further configured to transfer heat such that the transferred heat can pyrolyze at least some hydrocarbons in the part.

4105. (previously presented): The system of claim 4091, further comprising a valve coupled to at least one of the heaters configured to control pressure in at least a majority of the part of the formation.

4106. (previously presented): The system of claim 4091, further comprising a valve coupled to a production well configured to control a pressure in at least a majority of the part of the formation.

4107. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters to at least one portion of the formation, wherein the one or more heaters are disposed in one or more open wellbores in the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation;

maintaining a temperature in the part of the formation in a pyrolysis temperature range;

and

controlling the heat such that an average heating rate of the part of the formation is less

than about 1 °C per day during pyrolysis; and
producing a mixture from the formation.

4108. (previously presented): The method of claim 4107, wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

4109. (previously presented): The method of claim 4107, further comprising maintaining a temperature in the part in a pyrolysis temperature range with a lower pyrolysis temperature of about 250 °C and an upper pyrolysis temperature of about 400 °C.

4110. (previously presented): The method of claim 4107, wherein at least one of the heaters comprises an electrical heater.

4111. (cancelled)

4112. (previously presented): The method of claim 4107, wherein at least one of the heaters comprises a flameless distributed combustor.

4113. (previously presented): The method of claim 4107, wherein at least one of the heaters comprises a natural distributed combustor.

4114. (previously presented): The method of claim 4107, wherein the one or more heaters are suspended in the one or more open wellbores.

4115. (currently amended): The method of claim 4107, ~~wherein a tube is disposed in at least one of the open wellbores proximate to one of the heaters, and~~ further comprising flowing a substantially constant amount of fluid ~~in~~ into ~~at least one of the open wellbores through one or more critical flow orifices in the a tube disposed in the open wellbore proximate to one of the heaters.~~

4116. (currently amended): The method of claim 4107, ~~wherein a perforated tube is disposed in at least one of the open wellbores proximate to the heater, and further~~ comprising flowing a corrosion inhibiting fluid in into ~~at least one of the open wellbores through the a~~ perforated tube disposed in the open wellbore.

4117. (previously presented): The method of claim 4107, further comprising coupling an overburden casing to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation.

4118. (previously presented): The method of claim 4107, further comprising coupling an overburden casing to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein the overburden casing comprises steel.

4119. (previously presented): The method of claim 4107, further comprising coupling an overburden casing to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein the overburden casing is further disposed in cement.

4120. (previously presented): The method of claim 4107, further comprising coupling an overburden casing to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein a packing material is disposed at a junction of the overburden casing and at least one of the open wellbores.

4121. (previously presented): The method of claim 4107, further comprising coupling an overburden casing to at least one of the open wellbores, wherein the overburden casing is disposed in an overburden of the formation, and wherein the method further comprises inhibiting a flow of fluid between at least one of the open wellbores and the overburden casing with a packing material.

4122. (currently amended): The method of claim 4107, further comprising heating at least the ~~portion~~section of the formation to substantially pyrolyze at least some hydrocarbons in the formation.

4123. (previously presented): The method of claim 4107, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

4124. (cancelled)

4125. (previously presented): The method of claim 4107, further comprising controlling a pressure in at least a majority of the part of the formation with a valve coupled to at least one of the heaters.

4126. (previously presented): The method of claim 4107, further comprising controlling a pressure in at least a majority of the part of the formation with a valve coupled to a production well located in the formation.

4127. (cancelled)

4128. (currently amended): The method of claim 4107, wherein providing heat from the one or more heaters to at least the ~~portion~~section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.

4129. (previously presented): The method of claim 4107, wherein allowing the heat to transfer from the one or more heaters to the part comprises transferring heat substantially by conduction.

4130. (previously presented): The method of claim 4107, wherein providing heat from the one or more heaters increases a thermal conductivity of at least a portion of the part to greater than about 0.5 W/(m °C).

4131. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

4132. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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4133. (original): The method of claim 4107, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

4134. (original): The method of claim 4107, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

4135. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

4136. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

4137. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

4138. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

4139. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

① 4140. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

4141. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

4142. (original): The method of claim 4107, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

4143. (previously presented): The method of claim 4107, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the

molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

4144. (original): The method of claim 4107, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

4145. (original): The method of claim 4107, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

4146. (previously presented): The method of claim 4107, further comprising controlling a pressure in at least a majority of the part of the formation.

4147. (previously presented): The method of claim 4107, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

4148. (previously presented): The method of claim 4107, further comprising controlling formation conditions such that the produced mixture comprises a partial pressure of H₂ in the mixture greater than about 0.5 bar.

4149. (original): The method of claim 4148, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

4150. (previously presented): The method of claim 4107, further comprising recirculating a portion of hydrogen from the mixture into the formation.

4151. (previously presented): The method of claim 4107, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

4152. (previously presented): The method of claim 4107, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons
in the part; and

heating a portion of the part with heat from hydrogenation.

4153. (original): The method of claim 4107, wherein the produced mixture comprises hydrogen
and condensable hydrocarbons, the method further comprising hydrogenating a portion of the
produced condensable hydrocarbons with at least a portion of the produced hydrogen.

4154. (previously presented): The method of claim 4107, wherein allowing the heat to transfer
increases a permeability of a majority of the part to greater than about 100 millidarcy.

4155. (previously presented): The method of claim 4107, wherein allowing the heat to transfer
increases a permeability of a majority of the part of the formation such that the permeability of
the majority of the part is substantially uniform.

4156. (original): The method of claim 4107, further comprising controlling the heat to yield
greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer
Assay.

4157. (previously presented): The method of claim 4107, wherein producing the mixture
comprises producing the mixture in a production well, and wherein at least about 7 heaters are
disposed in the formation for the production well.

4158. (previously presented): The method of claim 4107, further comprising providing heat
from heaters to at least a portion of the formation, wherein the heaters are located in the
formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

4159. (previously presented): The method of claim 4107, further comprising providing heat
from heaters to at least a portion of the formation, wherein the heaters are located in the

formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

4160. (original): The method of claim 4107, further comprising separating the produced mixture into a gas stream and a liquid stream.

4161. (original): The method of claim 4107, further comprising separating the produced mixture into a gas stream and a liquid stream and separating the liquid stream into an aqueous stream and a non-aqueous stream.

4162. (original): The method of claim 4107, wherein the produced mixture comprises H_2S , the method further comprising separating a portion of the H_2S from non-condensable hydrocarbons.

4163. (original): The method of claim 4107, wherein the produced mixture comprises CO_2 , the method further comprising separating a portion of the CO_2 from non-condensable hydrocarbons.

4164. (original): The method of claim 4107, wherein the mixture is produced from a production well, wherein the heating is controlled such that the mixture can be produced from the formation as a vapor.

4165. (previously presented): The method of claim 4107, wherein the mixture is produced from a production well, the method further comprising heating a wellbore of the production well to inhibit condensation of the mixture in the wellbore.

4166. (original): The method of claim 4107, wherein the mixture is produced from a production well, wherein a wellbore of the production well comprises a heater element configured to heat the formation adjacent to the wellbore, and further comprising heating the formation with the heater element to produce the mixture, wherein the mixture comprises a large non-condensable hydrocarbon gas component and H_2 .

4167. (previously presented): The method of claim 4107, wherein the part is heated to a minimum pyrolysis temperature of about 270 °C.

4168. (previously presented): The method of claim 4107, further comprising maintaining the pressure in the formation above about 2.0 bar absolute to inhibit production of fluids having carbon numbers above 25.

4169. (previously presented): The method of claim 4107, further comprising controlling pressure in the formation in a range from about atmospheric pressure to about 100 bar, as measured at a wellhead of a production well, to control an amount of condensable hydrocarbons in the produced mixture, wherein the pressure is reduced to increase production of condensable hydrocarbons, and wherein the pressure is increased to increase production of non-condensable hydrocarbons.

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4170. (currently amended): The method of claim 4107, further comprising controlling pressure in the formation in a range from about atmospheric pressure to about 100 bar, as measured at a wellhead of a production well, to control an API gravity of condensable hydrocarbons in the produced mixture, wherein the pressure is reduced to decrease the API gravity, and wherein the pressure is increased to ~~reduce~~increase the API gravity.

4171-5395. (cancelled)

5396. (previously presented): The method of claim 4157, wherein at least about 20 heaters are disposed in the formation for each production well.

5397. (previously presented): The system of claim 4091, wherein the pyrolysis temperature range is from about 250 °C to about 400 °C.

5398. (previously presented): The method of claim 4107, further comprising providing H₂ to at least a portion of the formation.

5399. (previously presented): The method of claim 4107, further comprising providing H₂ to at least a portion of the formation to hydrogenate at least some hydrocarbons in at least the portion of the formation.

5400. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters to at least ~~one portion~~ a section of the formation, wherein the one or more heaters are disposed in one or more open wellbores in the formation, and wherein one or more heaters provide a heat output of less than about 1650 watts per meter;

allowing the heat to transfer from the one or more heaters to a ~~pyrolysis zone~~ part of the formation;

maintaining a temperature in the part of the formation in a pyrolysis temperature range;

flowing a corrosion inhibiting fluid into one of the open wellbores through a perforated tube that is disposed in the open wellbore; and

producing a mixture from the formation.

5401. (currently amended): The method of claim 5400, wherein ~~the pyrolysis zone comprises a selected section~~ at least one of the heaters comprises an electrical heater.

5402. (currently amended): The method of claim 5400, wherein at least one ~~heater~~ of the heaters comprises a natural distributed combustor.

5403. (currently amended): The method of claim 5400, ~~further comprising producing a mixture from the pyrolysis zone,~~ wherein the mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5404. (currently amended): The method of claim 5400, further comprising controlling a pressure and a temperature in at least a majority of the ~~pyrolysis zone~~part, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5405. (currently amended) The method of claim 5400, further comprising providing H₂ to at least a ~~portion of the formation~~the part.

5406. (currently amended): The method of claim 5400, further comprising providing H₂ to at least a ~~portion of the formation~~ to hydrogenate at least some hydrocarbons in at least the ~~portion~~section of the formation.

5407. (previously presented): The method of claim 5400, wherein the pyrolysis temperature range is from about 250 °C to about 400 °C.

5408. (currently amended): The method of claim 5400, wherein providing heat from the one or more heaters to the ~~portion~~section of the formation comprises:

heating a selected volume (V) of the formation from one or more of the heaters, wherein the formation has an average heat capacity ~~(C_v)~~ (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (*Pwr*) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (*h*) of the selected volume is about 10 °C/day.

5409. (new): The method of claim 5400, wherein at least one of the heaters comprises a flameless distributed combustor.